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-Technical Report-

"Development of the In-Dash Vehicle Display for the Fuel Efficient Demonstrator (FED) Alpha Vehicle"

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This technical document describes the development and integration of the in-dash vehicle display (IDVD) for the Fuel Efficient Demonstrator (FED) Alpha vehicle. The work was performed *from July 2010 to December 2010*, which resulted in an integrated display for the vehicle with touch screen capabilities. A brief overview of the FED Alpha is given, followed by a description of the IDVD system, its hardware and software. Finally, the function of the graphical user interface (GUI) is explained.

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Development of the In-Dash Vehicle Display for the Fuel Efficient Demonstrator (FED) Alpha Vehicle

Abstract

This technical document describes the development and integration of the in-dash vehicle display (IDVD) for the Fuel Efficient Demonstrator (FED) Alpha vehicle. The work was performed *from July 2010 to December 2010*, which resulted in an integrated display for the vehicle with touch screen capabilities. A brief overview of the FED Alpha is given, followed by a description of the IDVD system, its hardware and software. Finally, the function of the graphical user interface (GUI) is explained.

Note: Data displayed on screen shots of the IDVD GUI is a playback of software generated data and does not represent actually vehicle characteristics

Introduction of FED vehicle and the IDVD

The Fuel Efficient Demonstrator Program (FED) program resulted in the creation of 2 vehicles, FED Alpha and Bravo. The FED Alpha was designed using a conventional, systematic engineering approach, tightly collaborating with industry engineering talent and automotive suppliers. The FED program was established to explore the possibilities for gains in fuel economy. A small requirement of the FED Alpha program was to develop an in-dash vehicle display (IDVD). The IDVD was to have touch screen capability and display useful information to the driver and commander.

The development concept of the IDVD was to follow the design approach of the automotive industry. The overall aesthetics needed to be pleasing to the consumer, and it needed to provide real time data of the vehicle's situational awareness. A specific feature incorporated into the IDVD that would not normally have been put into a military display is a series of emotive graphics that coincide with the fuel performance of the vehicle. These emotive graphics give the driver feedback of how much fuel is being saved based on his/her driving characteristics, which encourages the driver to do better if fuel consumption is above a given threshold. Accordingly, the IDVD also gives the driver positive feedback if his/her fuel consumption is below a given threshold.

Figure 1: FED Alpha (Left) and Interior (Right) w/ In-Dash Vehicle Display

The IDVD hardware consisted of the ruggedized computer (VARTEC VTPC104PHB) running Windows OS and LabVIEW RTOS enclosed in a NEMA 4X (IP66) enclosure with a wide voltage input range. The connection to the CAN bus was realized with a USB to CAN interface, which connected to the FED's multiple CAN buses. The ruggedized computer consisted of a 10.4'' sunlight readable display with a resistive touch interface. A resistive touch interface was chosen opposed to a capacitive touch interface because capacitive touch technology does not work when the user wear gloves, as most soldiers do. The computer also provided ports to add additional input peripherals, such as keyboards and mice, as shown in Figure 2.

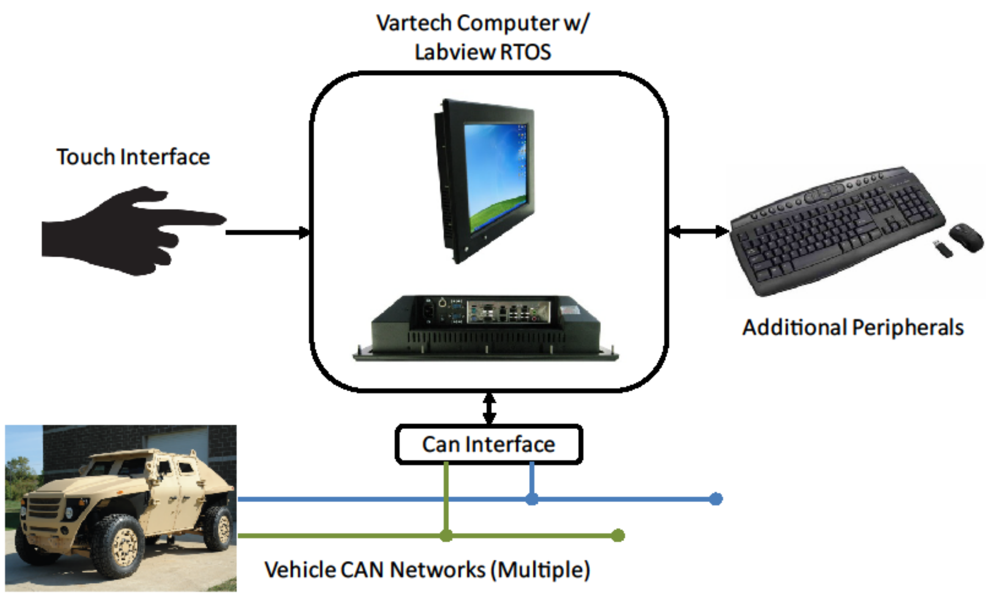

Figure 2: One wire system diagram of the IDVD interface

Graphical User Interface Development

The typical approach for LabVIEW based interfaces is to use built-in GUI objects that exist in the LabVIEW software, resulting in a clunky and lackluster design. The LabVIEW GUI objects are provided as means to create an interface for a laboratory in a quick and easy manner. Generally speaking, the LabVIEW environment is not used for highly customizable graphics GUIs. LabVIEW was the tool used to develop some vehicle subsystems in the lab environment, and from a project management standpoint it was better to customize the LabVIEW frontend rather than develop an entire new frontend in C++ or a similar GUI development environment. To ease integration of the customized graphics into LabVIEW, individual images where created for buttons, bar graphs, etc, and then swapped out with the existing LabVIEW libraries. Although time consuming, the brute force approach was the best method for adding customized graphics.

Figure 3: Early Concept of iDVD using built-in LabVIEW Graphics

To stylize the GUI environment to an aesthetically pleasing and automotive consumer friendly design, an industrial design company was hired to produce custom concepts for the IDVD which were then down selected. Down selection was chosen based on look, feel, and human factors. The initial concepts included a present day, World War II era, and two futuristic graphics sets as shown in Figure 4. Individual characteristics from each graphic set were combined in order to create a finalized graphics set for the FED Alpha vehicle: the gauges from the present day graphics set, the fuel consumption feedback indicator and side bar from the futuristic sets, etc. The final graphics set and the function of the GUI are described in the next section.

Figure 4: Graphics set concepts for IDVD screens

Individual Screen Description

The FED IDVD consisted of the following screens: a pedal feedback screen, a power consumption screen, a fuel economy screen, a navigation screen, an instrumentation screen, and an administration screen. The pedal feedback screen feedback data to the driver regarding the on board force feedback pedal. The power consumption screen kept power usage records and displayed the vehicle's loads. The fuel economy screen gave feedback to the driver about his/her driving performance based on fuel consumption. This screen was conceptualized after the Nissan Leaf and other similar hybrid-electric vehicles' in-dash displays. The navigation screen displays situational awareness data, and the instrumentation screen offers gauge displays not available on the physical gauge cluster. There was also a hidden administration screen that was used for testing and debugging the system.

Upon loading the application the main screen displayed a blank TARDEC logo and a common sidebar as shown in Figure 5. The common sidebar is present on every screen, and allows switching from one screen to the next. Upon depressing a screen button, or any other button, the button changes color and a finger print is shown to provide feedback to the user that the button is being pressed. This is indicated in Figure 6: Button untouched (left) and being pressed (right)Figure 6. Upon pressing the desired screen button, an arrow indicator shows the active screen. The administration screen is accessed by pressing the Ricardo button in the right hand bottom corner, illustrated in Figure 5. The next section explains each individual screen and its functions.

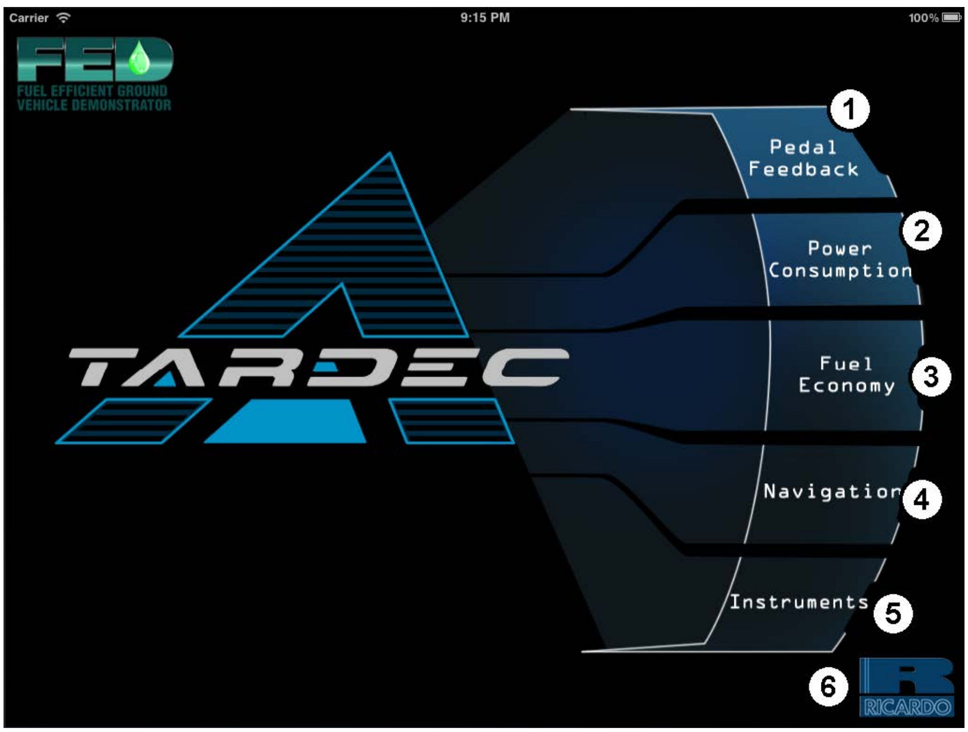

Figure 5: Main screen showing common sidebar with screen display buttons 1) Pedal Feedback 2) Power Consumption 3) Fuel Economy 4) Navigation 5) Instruments 6) Hidden button for admin

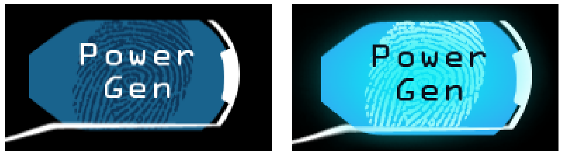

Figure 6: Button untouched (left) and being pressed (right)

Pedal Feedback Screen

The FED Alpha was equipped with a force feedback pedal that gave the driver input on his her driving behavior. If the driver accelerated too quickly, the pedal would vibrate so the driver would know the acceleration rate was not optimal to fuel performance. The pedal feedback screen consists of a bar graph showing how far the pedal's position is away from the target position and a scalable graph showing the pedal position offset over time.

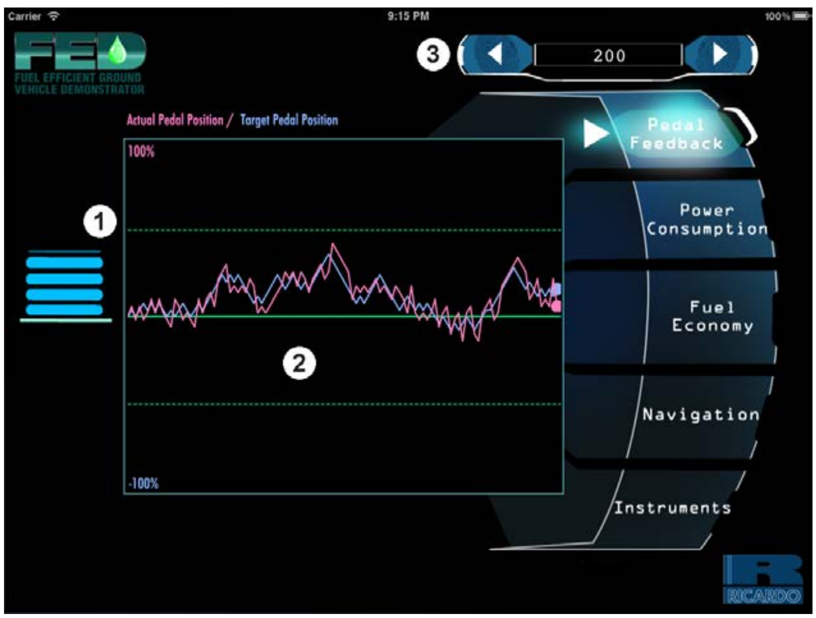

Figure 7: Pedal feedback screen showing pedal position indicator (1), time lapse graph of pedal displacement from target (2), and time scale (3)

The main feature of this screen was a graph of the force feedback pedal position versus time, with an adjustable time scale. The timescale can be adjusted by the buttons in the upper right hand portion of the screen (Figure 7), and the increments can be changed to any number at compile time. The graph displays two lines, the actual pedal position and the target pedal position. This gives the driver an understanding of how fuel efficient he/she is driving over a period of time.

The bar graph on the left, however, shows how close to the target pedal position the driver is actually at, i.e., an instantaneous readout. The bar graph's zero point is at the center of the screen, and the graph's height depicts how far pushed-in or pulled-out the pedal is from the target position. As the pedal position is close to zero, the graph turns green. At a medium distance the graph turns blue, and at a large distance the graph turns red as shown in Figure 8.

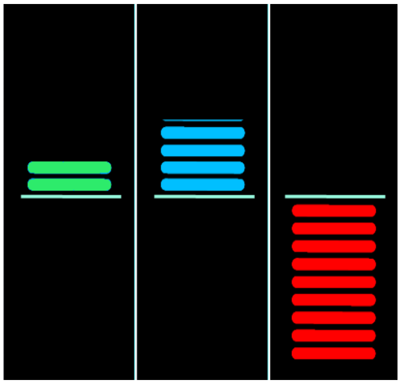

Figure 8: Good pedal displacement (green), moderate pedal displacement (blue), bad pedal displacement (red)

Power Consumption Screen

The power consumption screen keeps track of the instantaneous and average power load from all the subsystems of the vehicle. Viewers can see how much power systems are generating or how much power systems are drawing. From this information, users can then adjust system usages accordingly.

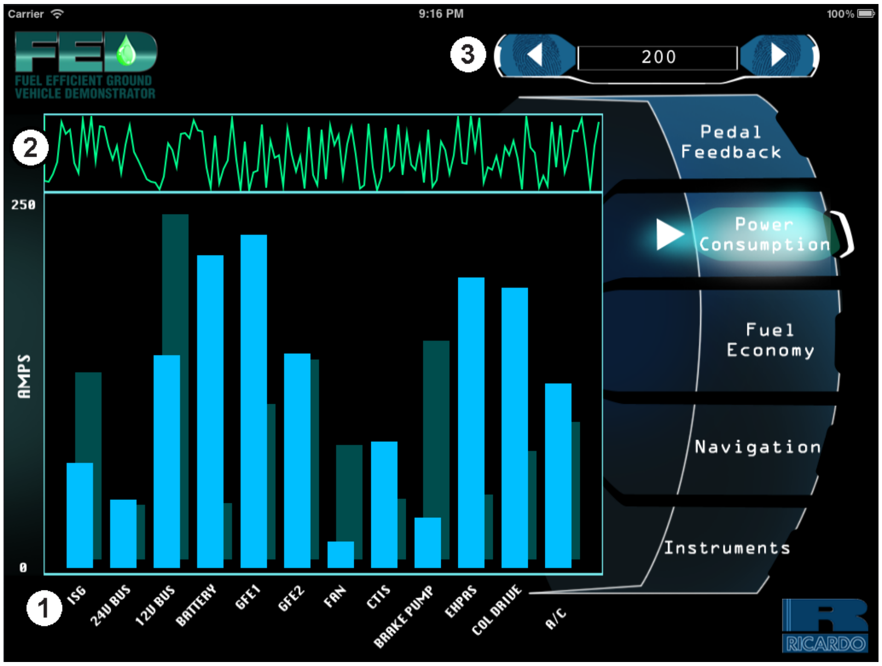

Figure 9: Power consumption screen bar display graph (1) time lapse graph (2) and time scale (3)

The main feature of this screen was to keep track of the power loads on the vehicle in order to determine where major power draws are coming from. The large bar graph, located in the left center of the Figure 9, shows both the instantaneous power draw and average power draw over a period of time. The instantaneous power draw is in bright blue in the foreground making it easier for the user to see, while the average power draw bars are located just behind that in a darker color. The time period for calculating the average power draw can be selected using the touch buttons in the upper right hand corner. The time scales can be programmed in during compile time. The line graph above the main bar graph (item 2, in Figure 9) represents the overall load of the vehicle.

Fuel Economy Screen

The fuel economy screen is the main screen for the IDVD. It was conceptualized after the display of the Nissan Leaf. As the driving behavior becomes more fuel efficient, the leaves and branches of the tree grow, giving the driver a fun and rewarding experience. As the driving behavior becomes less fuel efficient, leaves and branches fall from the tree. This concept was modeled into fuel economy screen, which is explained below in Figure 10.

Figure 10: Screenshot of Nissan Leaf's fuel economy screen

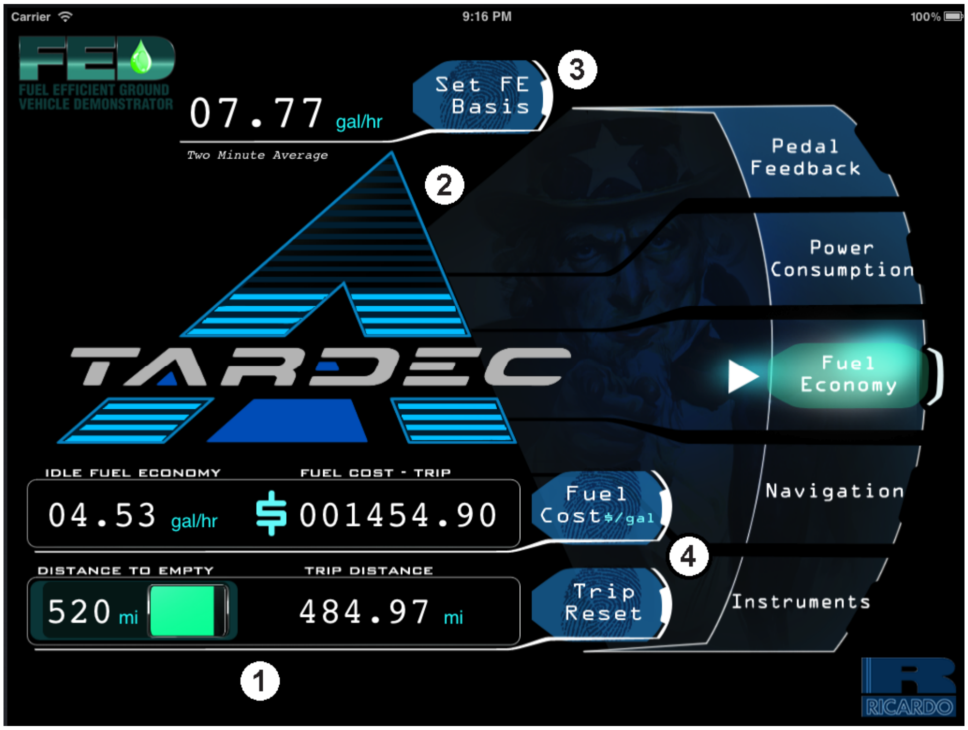

Figure 11: Fuel economy screen showing digial indicators (1) feedback logo (2) fuel economy analysis time base (3) and fuel cost and trip reset buttons (4)

The TARDEC logo is the main feature of this screen (shown as item 2 in Figure 11) which mimicked the Nissan Leaf's tree concept. Although the idea is similar, the functionality is slightly different. When the driver is driving in a fuel inefficient manner, the bars in the TARDEC logo will go down and changed color to red. Also, the background will glow red as well. Adversely, when the driver is driving in a fuel efficient manner, the bars in the logo will raise to the top and the background will change to a bright green glow. When the driving behavior is nominal, the color fades to blue and the glow disappears. This is shown in Figure 13. A driver's behavior can be essential to fuel economy. The positive and negative reinforcement can alter the driver's behavior to be more fuel efficient over time.

The fuel economy screen also offers a button for setting the FE basis in terms of an instantaneous, average, or trip-based calculation. The idle fuel economy is also shown. This is based on when the vehicle is in an idle mode and not driving. The driver can also see the total cost of the trip in dollars, and the dollar amount per gallon can be entered by hitting the fuel cost button. A screen will then pop up which will allow the user to enter a value (shown in Figure 12). The driver can also see a distance to empty value, with a corresponding gas tank like indicator that changes colors as the tank empties.

Figure 12: Fuel cost input screen

Figure 13: Fuel economy feedback indicators showing poor (left, red), nominal (middle, blue), and good (green, right) driving. Note the glow on red and green indicators.

Navigation Screen

The navigation screen is configurable to display situational awareness about the vehicle. Atmospheric data, GPS, and vehicle sensors such as tire pressure and shock fault sensors can be displayed. A top-down image of the vehicle shown on the right of Figure 14 displays low, tire air pressure warning as well as shock warnings. The highlighted box to the right of that displays GPS data, altitude and temperature data, both internal and external.

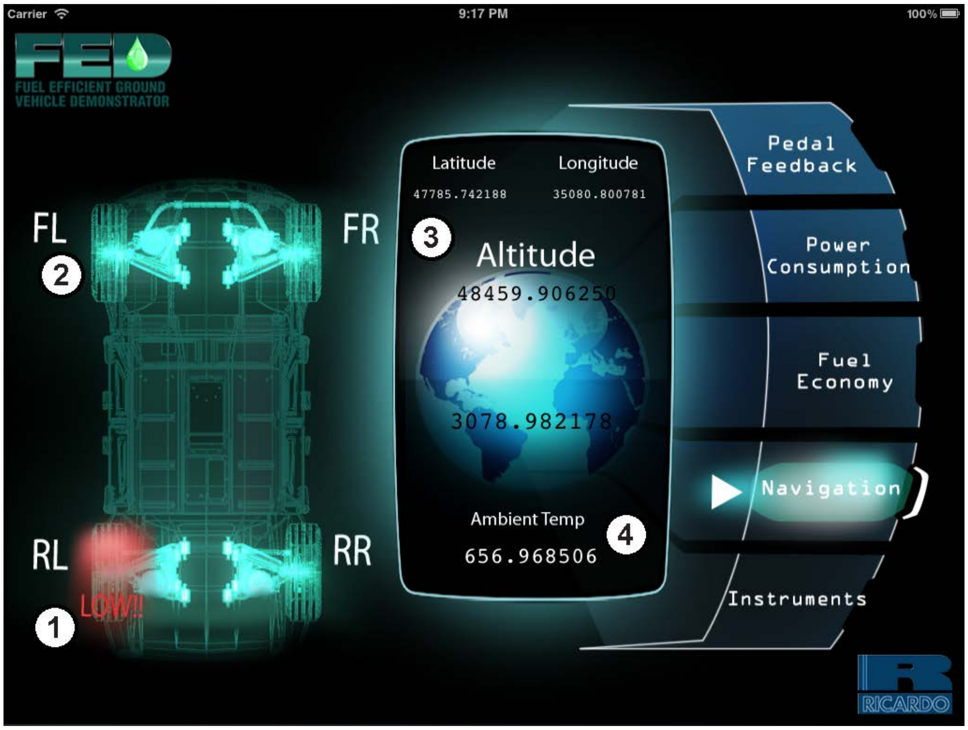

Figure 14: Navigation screen showing low tire pressure warnings (1), shock fault sensors (2), location data (3) and ambient conditions (4)

Instrument Screen

The instrument screen adds additional gauges to augment the drivers physical gauge cluster. The screen can switch between groups of gauges that are configurable during compilation of the software. Two groups of 7 gauges each can be selected for display: battery group and power generation group. The battery group consists of items related to the power being drawn from the vehicle whereas the power generation group shows the power coming from the Integrated Starter Generator (ISG).The gauges are designed to show the current value (shown by the needle), the maximum value (shown by the red dot) and the minimum value (shown by the blue dot). These values can be reset from the trip reset button on the main screen. See Figure 15

Figure 15: Close up of gauge, showing minimum value (blue dot), maximum value (red dot) and instantaneous value (green needle)

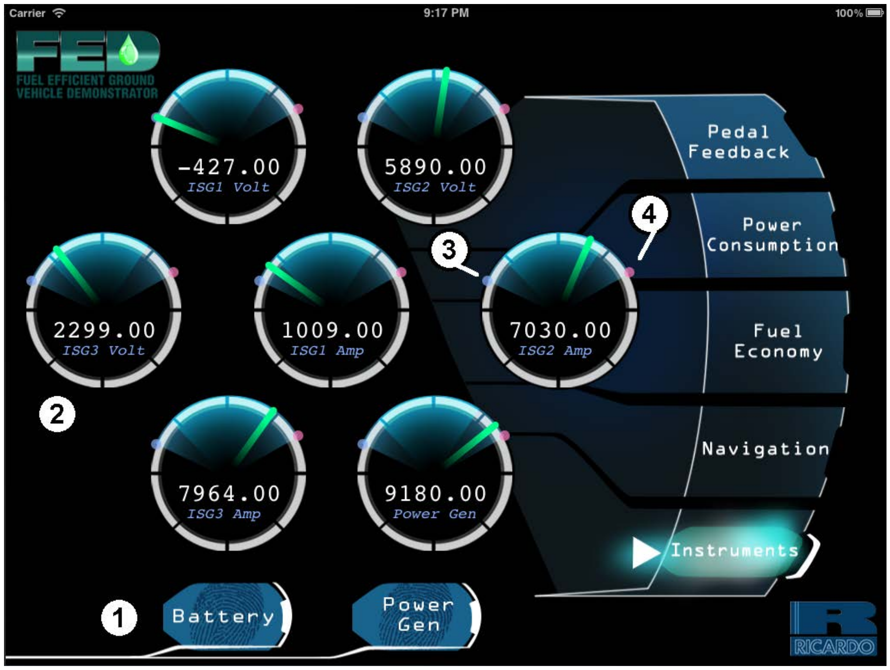

Figure 16: Instrument screen showing guage type selection (1), individual gauges with numeric and text readout (2), minimum (3) and max (4) indicator

Admin Screen

The administration screen is accessible by a hidden button and requires password verification to enter. Upon gaining access the user can switch between a demo mode and run mode, as well as turn on / off raw can bus messages. A demonstration mode is available for when the vehicle is at trade shows and the subsystems are not running. Also, CAN data is available for viewing to debug the system during developing and was left in the final software.

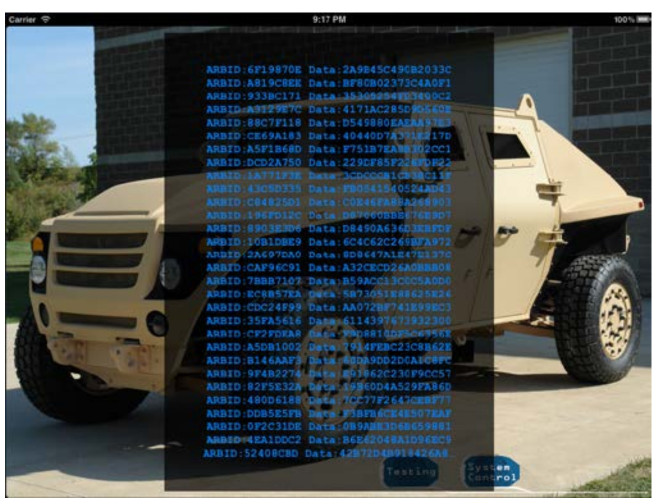

Figure 17: Example admin screen showing raw can bus data received by IDVD hardware

Results

After testing and development, the GUI was compiled to run on the IDVD computer and is now smoothly working in the vehicle as the main display. The aesthetics of the GUI were pleasing and modern due to the engagement of the industrial designer for the development of the GUI. However, the use of LabVIEW as a backend to run the GUI was a bad choice. The development time took longer than expected, and the period to establish a proper work flow also took longer than it should have. This was due to LabVIEW's inability to incorporate custom graphics directly, which resulted in the development many workarounds. However, once the work flow was established, the process moved along and the job was accomplished. Furthermore, when running LabVIEW on a desktop PC, the GUI runs slow due to the heavy graphical computations. Once compiled and deployed onto an operating system the GUI was able to meet bandwidth and reaction times and run smoothly. With the development of handheld computing tablets, the recommendation would be to follow a similar development process but on a tablet PC. (Note: the iPad was launched at the tail end of this project, and a port of the software was developed to run on the Apple iOS.) The benefits from using a tablet PC and developing a front in C++ or Qt outweighs the time saved by customizing LabVIEW graphics for a real time GUI.